Journal of Research and Curriculum Development, Vol.12, Issue.2, July – December, 2022
ISSN: 2730-387X (Online) https://so03.tci-thaijo.org/index.php/jrcd/index

Development of Training Curriculum to Enhance the Ability of Science Technology and Society Learning Management for Primary School Teachers

Chamras Intalapaporn[1*] Rattanawan Limwattanasamoot [2]
[1-2]Faculty of Education, Nakhon Pathom Rajabhat University, Nakhon Pathom, Thailand 73000
*Corresponding author e-mail: Chamras354@gmail.com

Received: September 4, 2022
Revised: November 8, 2022
Accepted: November 15, 2022

Abstract: *This study aims to: 1) develop a training curriculum to enhance the learning management ability based on science, technology, and society approach (STS) for primary school teachers; and 2) evaluate the effectiveness of the developed training curriculum in four aspects: 2.1) the knowledge and understanding of learning management based on science, technology, and society approach; 2.2) the ability of learning management based on science, technology, and society approach; 2.3) the result of STS lesson plan assessment of teachers 2.4)the students' learning skills based on science, technology, and society approach. The research methodology consists of four phases. Phase 1 is the study of fundamental data (R1). Phase 2 is drafting and validation of the developed training curriculum (D1). Phase 3 is the evaluation of training curriculum effectiveness (R2), which was divided into four steps: Step 1) a pilot study in which the developed curriculum was applied to non-sample group teachers; Step 2) a curriculum trial in which the developed curriculum was trialed with a sample group of Grade 4-6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture; Step 3) teachers organizing learning for students where teachers organized parallel-integrated learning classes for Grade 4-6 students in the Wat Phraprathon Chedi, Phraprathon Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Province; Step 4) seminar on connoisseurship to approve training curriculum by seven experts which to the training curriculum has effective according to the criteria and disseminate the training curriculum with group of Grade 3, 5-6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Donyaihom School, Donyaihom Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Province, and group of Grade 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Wat Sisa Thong School, Sisa Thong Subdistrict, Nakhon Chaisi District, Nakhon Pathom Province. Phase 4 is curriculum revision. The researcher revised the curriculum based on the feedback of Grade 4-6 teachers. The research instruments consisted of 1) an interview form for interviewing the school administrator and teachers, in which the obtained data were analyzed with content analysis; 2) a test of knowledge and understanding about learning management based on STS approach, in which the Sign Test were used to analyze the data; 3) an assessment form of learning management ability based on STS approach, in which data were analyzed with mean, and standard deviation; 4) an assessment form of lesson plans based on STS approach, in which data were analyzed with mean, and standard deviation; and 5) an assessment form of students' learning skills based on STS approach, in which data were analyzed with mean, and percentage. The statistics used for data analysis were mean, standard deviation, and the Sign Test.*

The results showed that 1) the training curriculum to enhance the learning management ability based on STS approach for primary school teachers comprises 1.1) problems and importance of the curriculum 1.2) curriculum principles 1.3) objectives 1.4) learning areas 1.5) training activities, consisting of 6 steps: 1.5.1) questioning, 1.5.2) planning, 1.5.3) finding answers, 1.5.4) giving reflection, 1.5.5) sharing experiences, 1.5.6) implementing; 1.6) training period 1.7) training materials and 1.8) evaluation of the curriculum. 2) The evaluation of curriculum effectiveness revealed that the developed training curriculum was effective according to the set criteria. Specifically; 2.1) the teachers' knowledge and understanding of learning management based on STS approach after training were higher than before training; 2.2) the teachers' learning management ability based on STS approach after training was at the highest level; 2.3) The result of STS lesson plan assessment of teachers after training was at the highest level; and 2.4) the students' learning skills based on STS approach after training were at high level and results of seminar on connoisseurship by seven experts showed that training curriculum has quality and appropriate for using with Grade 4-6 students. 3) The results of dissemination the training curriculum consist of two schools 3.1) the results of dissemination the training curriculum with group of Grade 3, 5 and 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Watdonyaihom School, Donyaihom Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Province, the results were that 3.1.1) the teachers' knowledge and understanding of learning management based on STS approach after training were higher than before training; 3.1.2) the teachers' learning management ability based on STS approach after training was at the highest level; 3.1.3) the result of STS lesson plan assessment of teachers after training was at the highest level; and 3.1.4) the students' learning skills based on STS approach after training were at high level. 3.2) the results of dissemination the training curriculum with group of Grade 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Wat Sisa Thong School, Sisa Thong Subdistrict, Nakhon Chaisi District, Nakhon Pathom Province, the results were that 3.2.1) the teachers' knowledge and understanding of learning management based on STS approach after training were higher than before training; 3.2.2) the teachers' learning management ability based on STS approach after training was at high level; 3.2.3) the result of STS lesson plan assessment of teachers after training was at high level; and 3.2.4) the students' learning skills based on STS approach after training were at high level.

Keywords: *Training curriculum, Learning management, Science, Technology and society approach*

Introduction

According to the results of the Ordinary National Educational Test (O-NET), in the academic year 2020, there were 495,223 students taking the test. The average score for science of the sixth graders was 38.78. When classified by learning area, it was found that the strand with the highest average score of 55.71 was Strand 1 biological sciences, followed by integration with an average score of 46.50, and the strand with the lowest average score of 32.50 was Strand 2 physical sciences, followed by Strand 3 earth and space sciences and Strand 4 technology with an average score of 36.50 and 33.13, respectively. It can be seen that the average scores for science of the 6^{th} grade in Strand 2-4 and integration are unsatisfactorily below 50% (National Institute of Educational Testing Service, 2020). Additionally, the study of operational problems of primary school teachers revealed teaching skill deficiencies of teachers. They do not have deep understanding of the subject due to the lack of teaching experience and continuous improvement. In addition, most of the teacher training programs in the past were required by the original affiliation, both in terms of course content and training methods, which did not correspond to the actual needs of teachers. On top of that primary school teachers lack knowledge, understanding, and ability to organize learning based on science, technology, and society approach (STS) (Office of the Education Council, 2020). Therefore, it is essential to provide teachers—especially in primary schools—knowledge, understanding, and ability of STS learning management. STS is the learning management that corresponds with social contexts and conditions and encourages learners to improve their knowledge of the nature of science. They will be aware that science, technology, and society are related. STS also enhances students to acknowledge science and technology, contribute to social problem solving, and have science process skills. They will be able to apply knowledge in new situations in family and community, have high thinking skills, be able to think and solve scientific problems, be able to work well with others, have good attitudes toward science, and love learning science. (Aikenhead, 1992; Chamrat, 2017; Pitiporntapin, 2015; Yager & Yager, 2006; Yutakom, 1999) In conclusion, the development of science teachers in primary education to have knowledge, understanding, and capability of organizing learning based on the STS concept is necessary. Recent studies have shown that there were research papers investigating the development of training programs for primary and secondary school teachers on the management of science learning using various integration concepts, such as STEM education (Klomim, 2019; Thongkantom, 2020) and nature of science (Sitthichaiyakarn, 2017). However, there is a lack of research on the development of a training curriculum to develop primary school teachers' ability to manage science learning using the STS approach, which research results have advantages for developing the quality of teachers and students.

Consequently, the researchers are interested in the development of a training curriculum for primary school teachers to enhance the ability of STS learning management. The objectives of the research were 1) to develop a training curriculum to enhance the learning management ability based on the STS approach for primary school teachers, and 2) to evaluate the effectiveness of the developed training curriculum in four aspects: 2.1) the teachers' knowledge and understanding of learning management based on STS approach; 2.2) the teachers' learning management ability based on STS approach; 2.3) the result of STS lesson plan assessment of teachers 2.4) the students' learning skills based on STS approach.

Research methodology

This research is a research and development consisting of four phases.

Phase 1 study of fundamental data (R1) consists of two following sub steps. 1.1 Interview of the school administrators and nine teachers teaching three strands for Grade 4-6: three from science and technology, three from career, and three from social studies, religion, and culture. The data collection tools included: 1) 21 interview questions for the school administrators on STS learning management with Index of Item-Objective Congruence (IOC) values between 0.67-1.00; and 2) 19 interview questions for teachers on STS learning management with IOC values between 0.67-1.00. 1.2 Synthesis of documents and research papers related to training curriculum development, learning management, and measurement and assessment based on the STS approach.

Phase 2 drafting and validation of the developed training curriculum (D1) consists of two sub steps. 2.1 The researcher applied the results of the study obtained from Phase 1 as a guideline for drafting the specification of training curriculum. The topics include 1) problems and importance of the curriculum; 2) principles; 3) objectives; 4) learning area; 5) training activities, consisting of 6 steps: 5.1) questioning, 5.2) planning, 5.3) finding answers, 5.4) giving reflection, 5.5) sharing experiences, and 5.6) implementing; 6) training period; 7) training materials; and 8) evaluation of the curriculum. 2.2 The quality of the training curriculum was examined through a focus group discussion of 5 experts, consisting of 1) two experts in curriculum and instruction, 2) two experts in science teaching, and 3) one expert in learning measurement and assessment. The appropriateness and feasibility of the developed training curriculum were validated, as well as the consistency of the curriculum elements before implementing the developed curriculum with the research sample. The IOC value was between 0.80-1.00. The quality of the draft training curriculum was validated using content analysis.

Phase 3 evaluation of the training curriculum effectiveness (R2) was divided into 4 steps. **In Step 1,** pilot study, the developed curriculum was trialed with three non-sample group teachers teaching three strands—science and technology, occupations, and society, religion, and culture—one teacher from each strand. The instruments consisted of 1) a four multiple-choice test of knowledge and understanding of STS learning management administered before and after teacher training. There were 20 items with IOC values between 0.50-1.00 and difficulty values between 0.2-0.8. The test reliability measured by Kuder-Richardson's KR-20 formula was 0.79. 2) A training curriculum to enhance learning management ability based on STS approach. **In Step 2,** implement the developed curriculum was trialed with the sample group of Grade 4-6 teachers teaching three strands—science and technology, occupations, and society, religion, and culture, three from each strand totaling nine teachers derived by multi-stage sampling and calculate the sample size by using G*POWER program version 3.1.9.7. The instruments consisted of 1) a four multiple-choice test of knowledge and understanding of STS learning management administered before and after teacher training. There were 20 items with IOC values between 0.50-1.00 and difficulty values between 0.2-0.8. The test reliability measured by Kuder-Richardson's KR-20 formula was 0.85. 2) A training course to enhance learning management ability based on the STS concept. **In Step 3**, the sample group teachers organized integrated-parallel learning for Grade 4-6 students in the Wat Phraprathon Chedi, Phraprathon Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Province. The instruments used consisted of 1) an assessment form of STS learning management ability. There were 24 items with IOC values between 0.67-1.00 and the reliability measured by Cronbach's alpha coefficient was 0.79. 2)

An assessment form of STS lesson plans. There were 21 items with IOC values of 1.00 and the reliability measured by Cronbach's alpha coefficient was 0.75. 3) An assessment form of students' learning skills based on STS approach with the reliability measured by Cronbach's alpha coefficient was 0.84. **In Step 4,** seminar on connoisseurship to approve training curriculum by seven experts which to the training curriculum has effective according to the criteria and disseminate the training curriculum with group of Grade 3, 5-6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Donyaihom School, Donyaihom Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Province, and group of Grade 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Wat Sisa Thong School, Sisa Thong Subdistrict, Nakhon Chaisi District, Nakhon Pathom Province.

Phase 4 curriculum revision (D2), the researcher revised the curriculum based on the feedback of Grade 4-6 teachers to complete the training curriculum.

Research results

1.The results of training curriculum development to Enhance the Ability of Science Technology and Society Learning Management for Primary School Teachers consist of four steps were followed:

1.1 Results of the fundamental data study (R1) were:

1) According to the interview of the school administrators and teachers, current conditions, problems, and needs of STS learning management were revealed. 1.1) In terms of the number of primary school teachers, there were not enough teachers allocated to all classes and subjects. 1.2) As for the school environment, there were many plastic bottles on the school grounds. 1.3) For learning management, primary school teachers lacked experience in STS learning management. 1.4) For the design of learning activities, primary school teachers were found lacking knowledge and understanding in this aspect. 1.5) For measurement and assessment, primary school teachers lacked knowledge, understanding, and experience in measuring and assessing learning outcomes based on STS approach.

2) Regarding the synthesis of documents and research papers on STS approach, it can be concluded that: 2.1) Regarding training curriculum concepts, training curriculum refers to the organization of experiences to develop teachers' knowledge, understanding, and ability to organize learning based on STS approach (Patphol, 2013; Royal Academy, 2012; Wongyai, 2011; Yothasing & Gumjudpai, 2016). The training curriculum developed by the researchers consists of eight components: 1) problems and importance of the curriculum; 2) principles; 3) objectives; 4) learning areas; 5) training activities, consisting of six steps: 5.1) questioning, 5.2) planning, 5.3) finding answers, 5.4) giving reflection, 5.5) sharing experience, and 5.6) implementing; 6) training period; 7) training materials; and 8) evaluation of the curriculum. 2.2) Regarding learning management based on STS approach, STS learning management refers to the integration of key concepts in 3 strands, namely, science, technology, and society. Teachers define problem situations that occur in society to encourage learners to participate in problem-solving using the scientific process. Thus, the ability to organize STS learning management refers to the ability to integrate the key concepts of science, technology, and society and use social issues to encourage learners to effectively participate in problem-solving through scientific process (Pitiporntapin, 2015; Primastuti & Atun, 2018; Songkathee, 2017). The STS learning management model comprises six steps: 1) questioning, 2) planning, 3) finding answer, 4)

giving reflection, 5) sharing experience, and 6) implementing. 2.3) Regarding concepts of STS measurement and assessment, STS measurement and assessment was found to be an authentic assessment corresponding to operation in schools through a knowledge and understanding test of STS learning management and an assessment form of STS lesson plans (Chamnan, 2014; Koonkaew, 2015; Nantasukhon, 2012; Patphol, 2018; Pitiporntapin , 2015; Promjouy, 2017; Sengsri, 2018; Wongyai & Patphol, 2015)

1.2 Results of the training curriculum drafting and quality validation (D1) The training curriculum developed by the researchers consists of eight components.

1) Problems and importance of the curriculum

According to the results of the Ordinary National Educational Test (O-NET), in the academic year 2020, there were 495,223 students taking the test. The national average score for science of the sixth graders was 38.78. When classified by strands, it was found that the subject with the highest average of 55.71 was Strand 1 biological sciences, followed by integration with an average score of 46.50. The subject with the lowest average of 32.50 was Strand 2 physical sciences, followed by Strand 3 earth and space sciences and Strand 4 technology with an average score of 36.50 and 33.13, respectively. It can be seen that the average score for science of sixth graders in Strand 2-4 and integration was at an unsatisfied level with an average score of below 50% (National Institute of Educational Testing Service, 2020). According to the interview of primary school teachers in a school in Nakhon Pathom Province, it was found that teachers lacked knowledge, understanding, and experience in integrated learning management with STS approach. Moreover, the number of teachers does not enough for all classes and subjects. To divide the workload to suit the number of available teachers, therefore, they have to teach several subjects. The problem is, regarding the results of the study of operational problems of primary school teachers, they did not have sufficient teaching capacity due to deficiencies in teaching skills and deep knowledge of the subject. This was the result from lacking teaching experience and continuous improvement. Also, teacher training in the past was normally determined by the organization and did not correspond to the actual needs of teachers (Office of the Education Council, 2020). Therefore, in order to raise learners' achievement, it is necessary to develop teachers, especially primary school teachers, to have knowledge, understanding, and capability to organize STS learning management, which is the learning management consistent with institutional and social contexts. STS learning management also encourages learners to have an understanding of the nature of science, get involved in solving social problems, have scientific process skills, be able to apply knowledge in new situations at home and in the community, have high thinking skills, be able to work with others, and have positive attitudes towards science. (Chamrat, 2017; Pitiporntapin, 2015; Yutakom, 1999)

2) Principles

There were six principles as follows: 1) It is a training curriculum to enhance the STS learning management ability for primary school teachers. 2) It is a curriculum that focuses on the integration of everyday-life situations. 3) It is a curriculum that prioritizes the integration of conceptual ideas in science and technology, occupations, and society. 4) It is a curriculum that gives importance to the sharing of learning and creative feedback. 5) It is a curriculum that emphasizes school-based teacher development with integration with routine work. 6) It is a curriculum that features the development of teachers using online technology.

3) Objectives

The curriculum had two objectives: 1) to provide teachers with knowledge and understanding of STS learning management, and 2) to equip teachers with the ability to organize learning based on STS approach.

4) Learning areas

The curriculum comprises 5 learning units as shown in Table 1.

Table 1 Learning areas

Learning Unit	Topic	Period
1	Analysis of STS Indicator	6 hours
2	Design of STS Learning Unit	6 hours
3	Preparation of STS Lesson Plans	6 hours
4	STS Learning Management and STS Measurement and Assessment	6 hours
5	Factors Contributing to Successful STS Learning Management	6 hours
Total		30 hours

5) The training activities

The training activities were divided into six steps as follows: **1) Questioning** is a process in which the training instructor divided teachers into groups of three and allowed each group to practice asking questions about school problems. After that, they jointly analyzed and selected three questions of urgent issues with problem-solving feasibility. **2) Planning** is the process in which each group of attending teachers jointly planned to analyze the problem and its cause, and found solutions to reduce the amount of plastic bottle waste in the school. **3) Finding answers** is a process in which teachers in each group jointly designed an innovative solution to reduce the amount of bottle waste in the school. Moreover, they jointly outlined the conceptual ideas and principles of science, technology, and society used in innovative design and group working processes. The researchers, the school administrators, and university academics coached teachers in each group. **4) Giving reflection** is a process in which teachers in each group jointly presented brooms made from plastic bottles and the work process. The researchers, the school administrators, and university academics jointly reflected on the ideas and suggested guidelines for the development of the teachers' work. **5) Sharing experience** is where teachers shared experience in developing plastic bottle brooms and shared their learning with other teachers, the researchers, the school administrators, and university academics in the form of professional learning community. **6) Implementing** the work is for teachers to experiment plastic-bottle brooms on different areas of the school, such as classrooms, grass lawns, etc., to assess the appropriateness and feasibility of use.

6) Training period: 5 days

7) Training materials included 1) PowerPoint presentation, 2) training materials, i.e., 2.1) indicators and core learning areas in science and technology (2017 revised version), 2.2) indicators and core learning areas in occupations, 2.3) indicators and core learning areas in social studies, religion, and culture, 2.4) five units of teachers' learning guideline, 2.5) training activity plans, and 2.6) plastic bottles.

8) Curriculum evaluation comprised 8.1) teachers' knowledge and understanding of STS learning management, 8.2) the STS learning management ability of teachers, 8.3) result of STS lesson plan assessment of teachers, 8.4) students' learning skills based on the STS approach.

The curriculum quality validation was conducted through a group discussion of five experts. They gave the following suggestions: 1) The curriculum principles should be clarified. 2) The name of the learning unit should be clearly revised. Generally, Unit 4 STS learning management should be combined with Unit 5 STS measurement and assessment. 3) The procedure for training activities should be written in formal language.

1.3 Results of training curriculum effectiveness evaluation (R2)

The evaluation of curriculum effectiveness was divided into four phases.

Phase 1 Results of pilot study. The developed training curriculum was trialed with a non-sample group of teachers. Teachers' learning outcomes were scores for teachers' knowledge and understanding of STS learning management of a non-sample group before and after training. Data were analyzed using Sign Test statistics. The results of the comparison of teachers' testing scores are shown in Table 2.

Table 2 Comparison of testing scores for teachers' knowledge and understanding of STS learning management before and after training of the non-sample group

Score	n	M	SD	N	X	Sign test
Before training	3	10.33	1.53	3	0	.01**
After training	3	14.67	0.58			

** Statistical significance level of .01

From Table 2, there was statistically significant difference at .01 in the testing scores for teachers' knowledge and understanding of STS learning management before and after training. Specifically, the testing scores after training was higher than before training.

Phase 2 Results of implement with the sample group

Teachers' learning outcomes included scores for teachers' knowledge and understanding of STS learning management of a sample group before and after training. Data were analyzed by Sign Test. The results show the comparison of testing scores for teachers' knowledge and understanding of STS learning management as shown in Table 3.

Table 3 Comparison of testing scores for teachers' knowledge and understanding of STS learning management before and after training of the sample group

Score	n	M	SD	N	X	Sign test
Before training	16	11.65	1.11	16	0	.01**
After training	16	15.29	1.31			

** Statistical significance level of .01

From Table 3, there was a statistically significant difference at .01 in the testing scores for teachers' knowledge and understanding of STS learning management before and after the training. Specifically, the testing score after training was higher than before training.

From monitoring and evaluating the STS learning management ability of teachers who teach science and technology, the results of data analysis are shown in Table 4.

Table 4 Mean for the STS learning management ability of teachers teaching science and technology for fourth to sixth graders

Grade	Assessors			M	SD	Quality Level
	No. 1*	No. 2**	No.3***			
Grade 4	4.98	4.87	4.29	4.73	0.34	Highest
Grade 5	4.98	4.78	4.30	4.68	0.35	Highest
Grade 6	4.98	4.87	4.37	4.74	0.34	Highest

1* Academics, 2** Researcher, 3*** School Administrators

From Table 4, it was found that mean for the STS learning management ability of teachers teaching science and technology was at the highest level.

From monitoring and evaluating the STS learning management ability of teachers who teach occupations, the results of data analysis are shown in Table 5.

Table 5 Mean for the STS learning management ability of teachers teaching Occupations for Grade 4-6 students

Grade	Assessors			M	SD	Quality Level
	No. 1*	No. 2**	No.3***			
Grade 4	4.98	4.87	4.29	4.71	0.37	Highest
Grade 5	4.98	4.76	4.31	4.68	0.36	Highest
Grade 6	4.98	4.87	4.59	4.81	0.22	Highest

1* Academics, 2** Researcher, 3*** School Administrators

According to Table 5, mean for the STS learning management ability of teachers teaching occupations strand was at the highest level.

From monitoring and evaluating the STS learning management ability of teachers who teach social studies, religion, and culture, the results of the data analysis are shown in Table 6.

Table 6 Mean for the STS learning management ability of teachers teaching social studies, religion, and culture for Grade 4-6 students

Grade	Assessors			M	SD	Quality Level
	No. 1*	No. 2**	No.3***			
Grade 4	4.88	4.70	4.16	4.58	0.42	Highest
Grade 5	4.85	4.74	4.73	4.77	0.12	Highest
Grade 6	4.84	4.87	4.50	4.74	0.21	Highest

1* Academics, 2** Researcher, 3*** School Administrators

According to Table 6, mean for the STS learning management ability of teachers teaching social studies, religion, and culture was at the highest level.

Phase 3 Results of teachers organizing learning for students where teachers organized parallel-integrated learning classes for Grade 4-6 students at Wat Phraprathon Chedi School, Phraprathon Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Province.

From evaluating the STS lesson plan of Grade 4 teachers teach learning unit Topic Trash from plastic bottles, the results of the data analysis are shown in Table 7.

Table 7 Mean for the STS lesson plan of Grade 4 teachers teach learning unit Topic Trash from plastic bottles

Topic	Learning Areas			Assessors			M	SD	Quality Level
	Science and Technology	Occupations	Social Studies, Religion and Culture	No. 1*	No. 2**	No.3***			
1. Material in everyday life	✓			4.95	4.76	4.14	4.62	0.42	Highest
2. Working process		✓		4.70	4.62	4.35	4.56	0.18	Highest
3. Problem in School			✓	5.00	4.74	4.57	4.77	0.22	Highest

1* Academics, 2** Researcher, 3*** School Administrators

According to Table 7, mean for the STS lesson plan of Grade 4 teachers teach learning unit Topic Trash from plastic bottles were at the highest level.

From evaluating the STS lesson plan of Grade 5 teachers teach learning unit Topic Chair from plastic bottles, the results of the data analysis are shown in Table 8.

Table 8 Mean for the STS lesson plan of Grade 5 teachers teach learning unit Topic Chair from plastic bottles

Topic	Learning Areas			Assessors			M	SD	Quality Level
	Science and Technology	Occupations	Social Studies, Religion and Culture	No. 1*	No. 2**	No.3***			
1. Food chain	✓			4.95	4.71	4.48	4.71	0.24	Highest
2. Appliances design		✓		4.76	4.55	4.62	4.64	0.11	Highest
3. Problem in school			✓	4.56	4.64	4.46	4.55	0.09	Highest

1* Academics, 2** Researcher, 3*** School Administrators

According to Table 8, mean for the STS lesson plan of Grade 5 teachers teach learning unit Topic Chair from plastic bottles were at the highest level.

From evaluating the STS lesson plan of Grade 6 teachers teach learning unit Topic Plantpot from plastic bottles, the results of the data analysis are shown in Table 9.

Table 9 Mean for the STS lesson plan of Grade 6 teachers teach learning unit Topic Plantpot from plastic bottles

Topic	Learning Areas			Assessors			M	SD	Quality Level
	Science and Technology	Occupations	Social Studies, Religion and Culture	No. 1*	No. 2**	No.3***			
1. Electrostatic	✓			5.00	4.81	4.43	4.75	0.29	Highest
2. Appliances invention		✓		5.00	4.86	4.62	4.83	0.19	Highest
3. Role of product manufacturer			✓	4.86	4.76	4.52	4.71	0.17	Highest

1* Academics, 2** Researcher, 3*** School Administrators

According to Table 9, mean for the STS lesson plan of Grade 6 teachers teach learning unit Topic Plantpot from plastic bottles were at the highest level.

From evaluating the students' learning skills based on STS approach after training were at high level, the results of the data analysis are shown in Table 10.

Table 10 Mean for the students' learning skills based on STS approach

Grade	Number of students	M	Percentage	Quality Level
Grade 4	12	43.67	87.34	High
Grade 5	15	45.50	91.00	High
Grade 6	16	45.67	91.34	High

According to Table 10, mean for the students' learning skills based on STS approach were at high level.

Phase 4 Results of seminar on connoisseurship to approve training curriculum by seven experts and dissemination the training curriculum with group of Grade 3, 5-6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Donyaihom School and group of Grade 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Wat Sisa Thong School.

4.1 Results of seminar on connoisseurship to approve the training curriculum by seven experts, the results of the data analysis are shown in Table 11.

Table 11 Results of the seminar on connoisseurship to approve the training curriculum by seven experts

No.	Assessment Item	Expert opinion		Quality Level
		M	SD	
1	Usefulness of Professional Development	4.86	0.38	Highest
2	Usefulness of Learner Development	4.71	0.49	Highest
3	Usefulness of Integrated Learning Management Innovation	4.86	0.38	Highest
4	Usefulness of School Quality Development	4.86	0.38	Highest
5	Usefulness of Education Quality Development	4.86	0.38	Highest

According to Table 11, mean of expert opinion level to approve the training curriculum were at the highest level.

4.2 Results of dissemination the training curriculum with group of Grade 3, 5-6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Donyaihom School, Donyaihom Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Province.

4.2.1 The teachers’ knowledge and understanding of learning management based on STS approach after training were higher than before training.

4.2.2 The teachers’ learning management ability based on STS approach after training was at the highest level.

4.2.3 The result of STS lesson plan assessment of teachers after training was at the highest level.

4.2.4 The students’learning skills based on STS approach after training were at high level.

4.3 Results of dissemination the training curriculum with group of Grade 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Wat Sisa Thong School, Sisa Thong Subdistrict, Nakhon Chaisi District, Nakhon Pathom Province.

4.3.1 The teachers' knowledge and understanding of learning management based on STS approach after training were higher than before training.

4.3.2 The teachers' learning management ability based on STS approach after training was at high level.

4.3.3 The result of STS lesson plan assessment of teachers after training was at high level.

4.3.4 The students' learning skills based on STS approach after training were at high level.

1.4 Results of curriculum revision (D2)

After the training, the school administrators and teachers attending the training commented on the developed curriculum as follows: 1) The training curriculum was appropriate for Grade 4-6 teachers and could be used for learning management to develop Grade 4-6 students. 2) Teachers had a better understanding of STS learning management. 3) The training activities encouraged teachers to participate in designing the STS integrated learning unit, titled plastic bottle brooms. This made teachers happy with the training.

2. Results of effectiveness evaluation of the curriculum to enhance the STS learning management ability for primary school teachers.

The results of the effectiveness evaluation of the training curriculum to enhance the STS learning management ability for primary school teachers are presented in Table 12.

Table 12 Results of effectiveness evaluation of the curriculum to enhance the STS learning management ability for primary school teachers

No.	Criteria for Effectiveness	Results of analysis	Conclusion
1	The teachers' knowledge and understanding of STS learning management after training is higher than before training with statistical significance at .01 level.	The teachers' knowledge and understanding of STS learning management after training is higher than before training with statistical significance at .01 level.	In accordance with the criteria
2	The STS learning management ability of teachers is at high level to the highest level with an average score of higher 3.51 of a full score of 5.	The STS learning management ability of teacher is at the highest level with an average score of higher 3.51 of a full score of 5.	In accordance with the criteria
3	The result of the STS lesson plan assessment of teachers is at high level to the highest level with an average score of higher 3.51 of a full score of 5.	The result of the STS lesson plan assessment of teachers is at the highest level with an average score of higher 3.51 of a full score of 5.	In accordance with the criteria
4	The students' learning skills based on STS approach is at high level	The students' learning skills based on STS approach is at high level	In accordance with the criteria
Results of curriculum effectiveness evaluation			In accordance with the criteria

Discussion

1. The developed training curriculum to enhance the STS learning management ability for primary school teachers consisted of eight components. 1) problems and importance of

the curriculum; 2) principles; 3) objectives; 4) learning areas; 5) training activities, consisting of six steps: 5.1) questioning, 5.2) planning, 5.3) finding answers, 5.4) giving reflection, 5.5) sharing experience, and 5.6) implementing; 6) training period; 7) training materials; and 8) evaluation of the curriculum. This developed curriculum is in line with the school contexts and teachers' needs since it was developed systematically according to the cycle of research and development (Royal Academy, 2012). The curriculum development process consists of four steps: 1) study of fundamental data (R1), 2) curriculum drafting and quality validation (D1), 3) evaluation of curriculum effectiveness (R2), and 4) curriculum revision (D2). The school administrators, teachers, academics, and the researchers worked together as a team in the form of professional learning community to kindly coach teachers on STS learning management. All teachers coordinated by sharing responsibilities, working together, and sharing learning with each other with good relationships. The school administrators, the researchers, and the academics provided feedback for the development of the teacher's learning management. (Chamrat, 2017; Euchuphap, 2018; Office of the Royal Society, 2015; Patphol, 2020; Pitiporntapin, 2015; Ratana-Ubol, 2020; Wongyai & Patphol, 2015).

2. The developed training curriculum was effective according to the following criteria:

2.1 The teachers' knowledge and understanding of STS learning management after training are statistically higher than before training at a level of .01. This was because the researcher prepared materials for teachers to study while attending training activities and systematically conducted teacher development. The training activities comprised six steps: 1) questioning, 2) planning, 3) finding answers, 4) giving reflection, 5) sharing experience, and 6) implementing. This is in line with the principle of school-based teacher development as an integrated on the job training, resulting in an average score of teachers' knowledge and understanding of STS learning management after training higher than before training (Euchuphap, 2018; Nopparak et al., 2014; Office of the Education Council, 2019; Patphol, 2018; Ratana-Ubol, 2020).

2.2 The STS learning management ability of teachers teaching 3 strands—science and technology, occupations, and social studies, religion, and culture—was at the highest level. This was because the researcher organized teacher training activities that encouraged teachers to participate in STS learning activities based on the school problems. There were many different sizes of plastic bottles being disposed of in the school. Each group of teachers was encouraged to participate in the analysis of conditions and causes of the problem, identify solutions to reduce the number of plastic bottles, and together design the innovative work, brooms from plastic bottles, to solve the problem. The following materials were used: 1) a PVC pipe, 2) a bamboo stick, 3) an electric drill, 4) a hammer, 5) a box of nails, 6) a box of bolts, 7) a roll of straw rope, 8) a basket, 9) different sizes plastic bottles: 750 cm^3, 1,500 cm^3, and 2,000 cm^3. In addition, the researchers provided an opportunity for each group to exchange learning experiences and present plastic bottle brooms. The school administrators, the researchers, and the academics provided feedback to guide the development of plastic bottle brooms. This activity is a professional learning community using a sharing and coaching process, including expert coaching, administrator coaching process, and peer coaching. Besides that, the school administrator, the teachers, academics, and the researcher organized meetings together to lesson-learned the success factor of the STS learning management of teachers teaching 3 strands—science and technology, occupations, and social studies, religion, and culture. The teachers realized that change of learning management role from instructor to coach for developed the quality of the students. Resulting in an average score of teachers' learning management ability based on STS

approach after training was at the highest level. (Chamrat, 2017; Chookhampaeng, 2022; Intanama & Wongwanich, 2014; Office of the Royal Society, 2015; Patphol, 2018; Pitiporntapin, 2015; Sabrina et al.; Wongyai & Patphol, 2018).

2.3 The result of the STS lesson plan assessment of teachers teaching science and technology, occupations, and social studies, religion, and culture was at the highest level. This was because 2.3.1) teachers were coached on writing STS lesson plans by the researcher, the school administrators, and academics. The lesson plans consisted of naming learning units, writing learning objectives, writing content, writing learning activities, selecting learning materials, and measuring and assessing according to actual conditions. This allowed teachers to write lesson plans that integrate STS concepts and organize classroom learning in line with the established lesson plans. 2.3.2) Teachers were reinforced by school administrators. They built teachers' morale and motivation with friendship, gave trust to teachers in preparing lesson plans, provided opportunities to think and make independent problem-solving decisions based on their own opinions and those of their group members, and set clear work goals. As a result, teachers could prepare efficient STS lesson plans in a timely manner. This is in accordance with the recent research of Ruchirat & Nillapun (2016) who revealed that empowerment is a process of encouraging and supporting teachers to achieve their goals. This process makes teachers confident in their abilities. They are motivated to work and empowered to act independently and participate in decision-making. Besides that, This is in accordance with the recent research of Tipkamontanakul (2019) who revealed that the empowerment of the school administrators were at high level, which support motivation of the teachers were at high level. Resulting in an average score of teachers' lesson plan assessment of teachers based on STS approach after training was at the highest level.

2.4 The students' learning skills based on STS approach were at high level. This is due to students being coached by teachers who clearly guide them through the activities and continuously give feedback on students' performance, maximizing the level of learning skills. This is in accordance with the concept of coach roles that have an effect on learners' learning. The learners who are coached by providing opportunities to engage in thinking and problem-solving by themselves will develop self-learning potential continuously. (Mok & Staub, 2021; Patphol, 2018; Wongyai & Patphol, 2015)

3. The results of dissemination the training curriculum consist of two schools

3.1 The results of dissemination the training curriculum with group of Grade 3, 5 and 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Watdonyaihom School, Donyaihom Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Province as followed.

3.1.1 The teachers' knowledge and understanding of STS learning management after training is statistically higher than before training at a level of .01. This was because the researcher prepared materials for teachers to study while attending training activities and systematically conducted teacher development. The training activities comprised six steps: 1) questioning, 2) planning, 3) finding answers, 4) giving reflection, 5) sharing experience, and 6) implementing. The teachers who are coached by school administrators, academics, and the researcher worked together as a team in the form of professional learning community to kindly coach teachers on STS learning management. (Office of the Royal Society, 2015; Ratana-Ubol, 2020; Wongyai & Patphol, 2015). All teachers coordinated by sharing responsibilities, working together, and sharing learning with each other with good relationships, which was in accordance with research of Chalermsri et al. (2021) who revealed that the teacher development by professional learning community process consisted

of willing and intention listening, open heart, reflection from member in each group lead to improve their work, include respect opinions of others, trust, sharing, reflection, friendly and positive cheer up, which promote the potential in learning management of teachers. Resulting in an average score of teachers' knowledges and understanding of STS learning management after training higher than after training.

3.1.2 The STS learning management ability of teachers teaching 3 strands—science and technology, occupations, and social studies, religion, and culture—was at the highest level. This was because the researcher organized teacher training activities that encouraged teachers to participate in STS learning activities based on the school problems. There were many different sizes of plastic bottles being disposed of in the school. Each group of teachers was encouraged to participate in the analysis of conditions and causes of the problem, identify solutions to reduce the number of plastic bottles, and together design the innovative work, such as plant pot, pencil sharpener, piggy bank, etc.,which support the teachers' knowledge and understand with hand on activities. The teachers were trained by the researcher about unit learning design, lesson plan writing, and guideline learning management and measurement and assessment based on STS approach from the researcher and academics, that support the teachers's knowledge and understand with STS learning management. The teachers who are coached by school administrators, academics, and the researcher worked together as a team in the form of professional learning community with friendship. The teacher have the experiences for the STS learning management, which was in accordance with the concept of professional learning community revealed that good relationship between school administrators, academics, the researcher and teachers worked together as the success factor of professional learning community. (Chookhampaeng, 2022; Office of the Royal Society, 2015; Wongyai & Patphol, 2018) Resulting in an average score of teachers' learning management ability based on STS approach after training was at the highest level.

3.1.3 The result of STS lesson plans assessment of teachers after training was at the highest level. This was because 1) teachers were trained with writing STS lesson plans by the researcher and academics, which support the teacher's knowledge, understand, and write effective STS lesson plans. 2) Teachers were coached guideline writing STS lesson plans based on STS approach by the researcher, the school administrators, and academics, which consisted the analysis of indicator, design learning unit, writing the learning objective, main idea, learning activities, learning media selection, and measurement and assessment based on STS approach, which support the teacher write effective lesson plan based on STS approach. 3) Teachers were reinforced by school administrators. They built teachers' morale and motivation with friendship, gave trust to teachers in preparing lesson plans, provided opportunities to think and make independent problem-solving decisions based on their own opinions and those of their group members, and set clear work goals. As a result, teachers could write efficient STS lesson plans by school administrators support the budget for learning media production. (Chomsavai et al., 2020; Chookhampaeng, 2022; Euchuphap, 2018; Office of the Royal Society, 2015; Suajoy, 2021). Resulting in an average score of teachers' lesson plan assessment of teachers based on STS approach after training was at the highest level.

3.1.4 The students' learning skills based on the STS approach after training were at high level. This is due to students in each group being coached by teachers about with guideline hand on activities. The students in each group assign the function in the work, plan working together, sharing together and present invention from plastic bottles such as pencil sharpener, piggy bank, model boat, etc., The students have knowledge and process

skill such as problem-solving skills, work together skills, science process skills, product design skills from the plastic bottles, etc. As a result, students feel be happiness and have a good attitude in the study in science and technology, occupations, and social studies, religion, and culture. Besides that, teachers guide their students through the activities and continuously give feedback on students' performance, maximizing the level of learning skills based on STS approach. This is in line with the concept of coach roles that have an effect on learners' learning. The learners who are coached by providing opportunities to engage in thinking and problem-solving by themselves will develop self-learning potential continuously. (Mok & Staub, 2021; Wongyai & Patphol, 2015; Wongyai & Patphol, 2018) Resulting in an average score of the students' learning skills based on the STS approach after training were at high level.

3.2 The results of dissemination the training curriculum with group of Grade 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Wat Sisa Thong School, Sisa Thong Subdistrict, Nakhon Chaisi District, Nakhon Pathom Province as followed,

3.2.1 The teachers' knowledge and understanding of STS learning management after training is statistically higher than before training at a level of .01. This was because the researcher introduces principles, objective, learning areas, training, training period, training materials; and evaluation of the curriculum before training. The researcher prepared materials for teachers to study while attending training activities and systematically conducted teacher development. The training activities comprised six steps: 1) questioning, 2) planning, 3) finding answers, 4) giving reflection, 5) sharing experience, and 6) implementing. This is in line with the principle of school-based teacher development as an integrated on the job training, resulting in an average score of teachers' knowledge and understanding of STS learning management after training higher than before training. (Euchuphap, 2018; Nopparak et al., 2014; Office of the Education Council, 2019; Patphol, 2018; Ratana-Ubol, 2020)

3.2.2 The STS learning management ability of teachers teaching 3 strands—science and technology, occupations, and social studies, religion, and culture—was at high level. This was because the researcher organized teacher training activities that encouraged teachers to participate in STS learning activities based on the school problems. There were many different sizes of plastic bottles being disposed of in the school. Each group of teachers was encouraged to participate in the analysis of conditions and causes of the problem, identify solutions to reduce the number of plastic bottles, and together design the innovative work. All teachers design learning unit in the title "Fancy Plantpot" which support the teachers' knowledge and understand about hand on activities. The teachers were trained by researcher about unit learning design, lesson plan writing, and guideline learning management and measurement and assessment based on STS approach from the researcher and academics, that support the teachers's knowledge and understand with STS learning management. (Chookhampaeng, 2022; Euchuphap, 2018; Wongyai & Patphol, 2018) Resulting in an average score of teachers' learning management ability based on STS approach after training was at high level.

3.2.3 The result of STS lesson plans assessment of teachers after training was at high level. This was because 1) teachers were trained with writing STS lesson plans by the researcher and academics, which support the teacher's knowledge, understand, and write effective STS lesson plans. 2) Teachers were coached guideline writing STS lesson plans based on STS approach by the researcher, the school administrators, and academics, which consisted of analysis of indicator, learning unit design, writing the learning objective, main

idea, learning activities, learning media selection, and measurement and assessment based on STS approach, which support the teacher write effective lesson plan based on STS approach. 3) Teachers were reinforced by school administrators. They built teachers' morale and motivation with friendship, gave trust to teachers in preparing lesson plans, provided opportunities to think and make independent problem-solving decisions based on their own opinions and those of their group members, and set clear work goals. As a result, teachers could write efficient STS lesson plans by school administrators support the budget for learning media production, which was in accordance with the concept of professional learning community revealed that principal support as the first success factor of professional learning community. (Chookhampaeng, 2022; Hunzicker, 2011; Wongyai & Patphol, 2018) Resulting in an average score for the STS lesson plans assessment of teachers after training was at high level.

3.2.4 The students' learning skills based on the STS approach after training were at high level. This is due to students in each group being coached by teachers about with guideline hand on activities. The students in each group assign the function in the work, plan working together, sharing together and present invention from plastic bottles in the title "Fancy Plant Pot." The students have knowledge and process skill such as problem-solving skills, work together skills, science process skills, product design skills from the plastic bottles, etc. As a result, students feel be happiness and have a good attitude in the study in science and technology, occupations, and social studies, religion, and culture. Besides that, teachers guide their students through the hand on activities and continuously give feedback on students' performance, maximizing the level of learning skills based on STS approach. This is in line with the concept of coach roles that have an effect on learners' learning. The learners who are coached by providing opportunities to engage in thinking and problem-solving by themselves will develop self-learning potential continuously. (Mok & Staub, 2021; Patphol, 2018; Wongyai & Patphol, 2015) Resulting in an average score of the students' learning skills based on the STS approach after training were at high level.

Conclusion

1. The developed training curriculum to enhance the STS learning management ability for primary school teachers consisted of eight components. 1) problems and importance of the curriculum; 2) curriculum principles; 3) objectives; 4) learning areas; 5) training activities, consisting of six steps: 5.1) questioning, 5.2) planning, 5.3) finding answers, 5.4) giving reflection, 5.5) sharing experience, and 5.6) implementing; 6) training period; 7) training materials; and 8) evaluation of the curriculum.

2. The developed training curriculum is effective according to the set criteria:

2.1 The teachers' knowledge and understanding of STS learning management after training was higher than before training.

2.2 The STS learning management ability of teachers after training was at the highest level.

2.3 The result of STS lesson plan assessment of teachers after training was at the highest level

2.4 The students' learning skills based on the STS approach after training were at high level.

3. The results of dissemination the training curriculum consist of two schools

3.1 The results of dissemination the training curriculum with group of Grade 3, 5 and 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Watdonyaihom School, Donyaihom Subdistrict, Mueang Nakhon Pathom District, Nakhon Pathom Province.

3.1.1 The teachers' knowledge and understanding of STS learning management after training is statistically higher than before training at a level of .01.

3.1.2 The STS learning management ability of teachers after training was at the highest level.

3.1.3 The result of STS lesson plan assessment of teachers after training was at the highest level.

3.1.4 The students' learning skills based on the STS approach after training were at high level.

3.2 The results of dissemination the training curriculum with group of Grade 6 teachers teaching in three strands, i.e., science and technology, occupations, and social studies, religion, and culture in the Wat Sisa Thong School, Sisa Thong Subdistrict, Nakhon Chaisi District, Nakhon Pathom Province.

3.2.1 The teacher's knowledge and understanding of STS learning management after training is statistically higher than before training at a level of .01.

3.2.2 The STS learning management ability of teachers after training was at high level.

3.2.3 The result of STS lesson plans assessment of teachers after training was at high level.

3.2.4 The students' learning skills based on the STS approach after training were at high level.

References

Aikenhead, G.S. (1992). Integrating STS into science education. *Theory into Practice, 31*(1), 27-35. http://doi.org/10.1080/00405849209543521

Chalermsri, A. Seekheio, D., & Siripatharachai, P. (2021). Development of the active learning management abilities of elementary teachers through the professional learning community process. *Journal of Social Science and Buddhistic Anthropology, 6*(4), 176-191.

Chamnan, K. (2014). *Effects of Instructional Integration of Science, Technology, and Society on abilities in analyzing and using Science knowledge of lower Secondary School Students, Nan Province.* [Master' s thesis, Chulalongkorn University].

Chamrat, S. (2017*). Science Instruction by using Science, Technology, and Society Approach in Provision of Foundations and Methodologies and Nature of Science Unit 6-10*. (4th ed.). The Office of the University Press Sukhothai Thammathirat Open University.

Chomsavai, T., Sathapornphojana, S., & Chaloeywates, N. (2020). Empowerment for teachers in the 21st century. *Journal of Legal Entity Management and Local Innovation, 6*(1), 123-136.

Chookhampaeng, C. (2022). *Learning community to classroom research.* Chulalongkorn University Printing House.

Euchuphap, P. (2018). *Education and teaching profession.* Chulalongkorn University Printing House.

Hunzicker, J. (2011). Effective professional development for teachers: A checklist. *Professional Development in Education, 37*(2), 177-179. http://doi.org/10.1080/19415257.2010.523955

Intanama, N. & Wongwanich, S. (2014). An application of the professional learning community approach to developing the learning process and enhancing academic achievement in the mathematics and science teaching of the primary school student. *Social and Behavioral Sciences, 131*, 476-483.

Klomim, K. (2019). A training curriculum development on introduction STEM with integrated King's science education for primary teachers. *Veridian E-Journal, Silpakorn University, 12*(1), 1,391-1,413.

Koonkaew, A. (2015). *Measurement and evaluation new education.* Chulalongkorn University Printing House.

Mok, S.Y., & Staub, F.C. (2021). Does coaching, mentoring, and supervision matter for pre-service teachers' planning skills and clarity of instruction? A meta-analysis of quasi-experimental studies. *Teaching and Teacher Education, 107*, 1-14. http://doi.org/10.1016/j.tate.2021.103484

Nantasukhon, R. (2012). *Principle of measurement and education evaluation.* (4th ed.). Golden Point.

National Institute of Educational Testing Service. (2020). *Summary of ordinary national educational test for primary 6 students in exam 2 0 2 0* . http://www.newonetresult.niets.or.th/AnnouncementWeb/PDF/SummaryONETP6_2563.pdf

Nopparak, S., Mejang, S., Panitplinchai, T., Wattanatorn, A., & Panawong, C. (2014). School-based development model for teachers and administrator small-sized schools: A case of Phitsanulok province. *Journal of Education Naresuan University*, *16*(4), 141-154.

Office of the Education Council. (2019). *The development of paradigm, pattern and mechanism on the teacher development in 5 area-based networks.* Prikwarn Graphic.

Office of the Education Council. (2020). *Thai education situation 2561/2562 education reform in digital era.* Parbpim.

Office of the Royal Society. (2015). *Contemporary education vocabulary*. Chia Hua.

Patphol, M. (2013). A Training curriculum development to enhance research-based instruction for teachers**.** *Journal of Research and Curriculum Development, 3*(1), 15-27.

Patphol, M. (2018). *Curriculum evaluation for jearning and development.* (4th ed. expand details from experiences practice and research). Charansanitwong Printing.

Patphol, M. (2020). Research and development for innovative curriculum & instruction. *Silpakorn Educational Research Journal, 12*(1), 1-16.

Pitiporntapin, S. (2015*). Science learning management with social in 21st century*. Boss Printing.

Primastuti, M., & Atun, S. (2018). Science Technology Society (STS) learning approach: An effort to improve students' learning outcomes. *Journal of Physics: Conf. Ser.*1097, 1-7. https://doi:10.1088/1742-6596/1097/1/012062

Promjouy, S. (2017). Unit 13 measurement and evaluation science instruction in *Foundations and Methodologies of Nature of Science Unit 11-15*. The Office of the University Press Sukhothai Thammathirat Open University.

Ratana-Ubol, A. (2020). *Lifelong education promotion approach in Thai society.* (2nd ed.). Chulalongkorn University Printing House.

Royal Academy. (2012). *Education vocabulary dictionary.* Aroonkarnpim.

Ruchirat, S., & Nillapun, M. (2016). An empowerment model to develop instructional competency of teachers to promote happiness learning of primary students. *Veridian E-Journal, Silpakorn University*, *9*(1), 780-794.

Sabrina, A., Lonneke, A. L., & Sabine E. S. (2021). Improving culturally responsive teaching through professional learning communities: A qualitative study in Dutch pre-vocational schools. *International Journal of Educational Research, 105*, 1-11. https://doi.org/10.1016/j.ijer.2020.101698

Sengsri, S. (2018). *Instruction methodology: Computer strand information and communication technology (ICT) strand technology.* Nawamit Printing Company.

Sitthichaiyakarn, S. (2017). The development of a training curriculum to enhance the ability of secondary teachers in the learning management of the integrated nature of science. *Veridian E-Journal, Silpakorn University*, *10*(2), 1,076-1,088.

Songkathee, B. (2017). *Learning management with Science, Technology and Society (STS) approach to promote student's understanding of nature of science for matthayomsuksa six students*. [Master's thesis, Nakhon Sawan Rajabhat University].

Suajoy, W. (2021). *The empowerment of administrators and teacher professional standards performance in school under Singburi Primary Educational Service Area.* [Master's thesis, Silpakorn University].

Thongkantom, J., Sathiennoppakao, P., & Pengsawat, W. (2020). Development of a training curriculum in stem education learning management for teachers in an opportunity expansion school under the Sakon Nakhon Primary Educational Service Area Office1. *Journal of Roi Et Rajabhat University, 14*(3), 32-40.

Tipkamontanakul, W. (2019). *The empowering of administrator and motivation in teacher performance under the Secondary Educational service Area Office 9.* [Master' s thesis, Silpakorn University].

Wongyai, W. (2011). *Curriculum development in higher education*. R and Print.

Wongyai, W. & Patphol, M. (2015). *Cognitive coaching.* Charansanitwong Printing.

Wongyai, W. & Patphol, M. (2015). *From core curriculum to school curriculum: Development in new paradigm* (7th ed.). Charansanitwong Printing.

Wongyai, W. & Patphol, M. (2018). *New frontier of learning to future creativity.* Charansanitwong Printing.

Yager, R. E., Lim, G., & Yager, R. E. (2006). The advantages of an STS approach over a Typical Textbook dominated approach in middle school science. *School Science and Mathematics, 105*(5), 248-260. https://doi.org/10.1111/j.1949-8594.2006.tb 18083.x

Yothasing, A., & Gumjudpai, S. (2016). Development of a training curriculum based on the concept of blended learning for enhancing primary school teacher's competency of student-centered assessment. *Silpakorn Educational Research Journal*, *8*(2), 270-284.

Yutakom, N. (1999). Learning experience in science by using Science, Technology, and Society-STS Model. *Journal of Kasetsart Educational Review, 14*(3), 29-48.